

Project report: Cane2Fuel: Developing an optimised and sustainable sugarcane biomass input system for the production of second generation biofuels



Lead organisation: BSES Limited

Project partners: CSIRO

Project commencement and completion date: December 2009 - May 2012

Project summary

The Cane2Fuel project embraced the progression towards second generation biofuels technology by focussing on the sugarcane biomass supply chain in Australia. It was supported through the Second Generation Biofuels Research and Development (Gen 2) Program, which supported the research, development and demonstration of new biofuel technologies and feedstocks that address the sustainable development of an advanced biofuels industry in Australia.

Cane2Fuel was designed to deliver a package of outcomes to ensure the long term sustainable supply of sugarcane based biomass to make biofuels. The use of sugarcane fibre does not impact on the food versus fuel debate as the part used is a natural waste product of the sugar production process and could not be used otherwise. The project included: breeding and selection of suitable varieties of sugarcane; optimising farming practices to maximise the production of biomass; developing laboratory methods for analysing biomass; and developing measurement tools to assess biomass quality and process control solutions. This package will be applicable across many different biofuel production technologies and different crops and cropping systems.

The project concluded that it is not currently economic to produce biofuels from lignocellulosic material left over after sugarcane processing. This was not a surprising outcome but is expected to change in the short to medium term as improvements in conversion technology, operating and capital cost reductions, feedstock supply, reduced emissions and compelling market forces for second generation biofuel production and consumption drive technology uptake.

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Project scope

An integrated program of research, development and commercialisation activities was undertaken to describe the technical and commercial feasibility of produce biofuels from sustainable lignocellulosic material left over after sugarcane processing. The project was a collaborative effort led by BSES Limited, the principal research, development and extension provider to the Australian sugar industry, and CSIRO Plant Industry.

The principal outcomes were anticipated to be:

- A description of the technical and commercial feasibility of second generation biofuel production from sugarcane biomass;
- The development of methods for, and characterisation of, the suitability of sugarcane varieties for second generation biofuel production;
- A description of a sugarcane production system for biofuel production; and
- The preparation of a prospectus sufficient to attract investment in a pilot scale second generation biofuel plant at an Australian sugar mill.

These objectives were achieved, although the prospectus seems premature considering lignocellulosic fuel conversion technologies are not yet commercial, and the project found it is not currently economic to produce biofuels from lignocellulosic material left over after sugarcane processing.

Outcomes

1. Biomass characterisation and examining sugarcane diversity

Cane2Fuel successfully:

- implemented US National Renewable Energy Laboratory (NREL) standard methods for characterising biomass;
- developed in-house laboratory methods for analysing sugar cane types; and
- developed a comprehensive collection of sugarcane biomass samples with an analysis of sugarcane diversity.

2. Optimising biomass production using existing commercial sugarcane varieties

Attempts have been made to maximise biomass production in the field using existing commercial sugarcane varieties. Accelerated harvesting regimes did not enhance biomass production, confirming there is alignment with existing processes, current best management practices and future requirements for biomass production; however this means it is not currently economic to produce biofuels from lignocellulosic material left over after sugarcane processing.

3. Genetic improvement of sugarcane for biofuels production

Breeding strategies have been determined for the production of high fibre sugarcane varieties and an appropriate breeding subprogram has been defined. Further work may yield breeding strategies that can exploit the genetic characteristics of sugarcane species with the result seeing a combination of the economic and genetic information used to deliver varieties which maximise whole-of-industry economic returns for biofuel production.

4. Development of rapid methods of biomass characterisation based on near-infrared (NIR) technology

Methods were developed to transfer near-infrared measurement systems developed in the laboratory to plant breeding. This will help to enhance the breeding, selection and production of high biomass sugarcane varieties.

5. Application of online NIR measurement systems for biomass analysis at biomass processing facilities

A biomass NIR measurement system was developed and trialled in a bagasse (a waste product of sugar production) analysis system. This demonstrated that online NIR measurement systems can be used in practical applications. A commercial system has been designed that can be integrated at the front-end of biorefineries and handle various feedstocks, not just sugarcane.

6. Pre-commercialisation activities with partner(s).

Economic and financial models have been developed to examine the income-cost structure for biofuel production using current available information as well as provide a basis to review and evaluate different options for using bagasse. Partnerships with research and commercial organisations will expand methods for feedstock analysis and broaden options for implementation within future scenarios.

Products, patents (applied/granted) and publications produced as part of the project

The online near-infrared measurement system, which can be integrated at the front-end of biorefineries and handle various feedstocks, not just sugarcane, has been produced and is available for use. Biomass calibrations have been produced for sugarcane and are available for incorporation within existing Cane Analysis System (CAS) and Bagasse Analysis System (BAS) instruments. Subsequent work conducted outside of the Cane2Fuel project with a University of Queensland based project team is examining the extension of this work to include additional biomass feedstocks such as eucalyptus and forest products.

A number of publications have been produced relating to the project. These include :

- Simpson, J., Staunton, S. and O'Shea, M. (2012). A review of NIR applications for process control purposes. *International Sugar Journal*, 114(1358):91-95.
- Fong Chong, B and O'Shea MG (2012). Developing sugarcane lignocellulosic biorefineries - opportunities and challenges. *Biofuels*, 3(3):307-319.
- Oxley J, Fong Chong B and O'Shea MG (2012). Accelerating the characterisation of sugarcane biomass using near-infrared (NIR) spectroscopic techniques. *Proceedings of the Australian Society of Sugar Cane Technologists*, 34: 9p.
- Fong Chong B, Purcell DE and O'Shea MG (2012). Diffuse reflectance, near-infrared spectroscopic estimation of sugarcane lignocellulose components - Effect of sample preparation and calibration approach. *Bioenergy Research*, 6(1):153-165.
- Fong Chong, B and O'Shea MG (2013). Advancing energy cane cell wall digestibility screening by near-infrared spectroscopy. Submitted to *Applied Spectroscopy*.
- Salter B, Park G and Schroeder B (2013). Does harvesting sugarcane crops more frequently increase biomass production? *Proceedings of the Australian Society of Sugar Cane Technologists*, 35: 8p.
- O'Shea MG, Keefe EC, Fong Chong B, Burns EM and Oxley JP (2013). An analysis of the lignocellulosic diversity of sugarcane. *Proceedings of the International Society of Sugar Cane Technologists*, 28: 10p.

Ancillary benefits

The analytical chemistry and near infrared (NIR) tools developed within the Cane2Fuel project are being employed in various partnerships to enhance the likelihood of commercialising second generation biofuel technologies. There are two current partnerships where these Cane2Fuel outcomes are being used.

- CSIRO/BSES project entitled "Developing sugarcane for production systems utilising total biomass". This project is funded by the Sugar Research and Development Corporation (SRDC) and will conclude at the end of 2013. It is striving to facilitate the development of sugarcane varieties which are suited to the future production of both sugar and biofuels from the same plant. Project

objectives are to characterise sugarcane germplasm regarding traits which are important for biomass production, estimate genetic gains that could be achieved using standard plant breeding and selection techniques, and to make future recommendations for sugarcane breeding in Australia to best deliver varieties for future production systems based on higher biomass requirements.

- University of Queensland/BSES/Clemson University project entitled "Development of sustainable second generation biomass crops and conversion technologies for biomaterial production". This project is funded by the Queensland Government Smart Futures Fund and will conclude during 2014. The project is examining proprietary conversion technologies and matching them with bioenergy crops such as sugarcane, eucalyptus and legumes in order to deliver technical and commercial proof of concept for biomass production and conversion.

Effectiveness

To create a sustainable lignocellulosic ethanol business, a cost-effective supply of sufficient quantities of biomass is required. Sugarcane is an ideal feedstock for the production of second generation biofuels insofar as it is a very efficient biomass crop and infrastructure is already in place for planting, growing, harvesting and processing the crop, as well as transporting, storing and shipping of final products. The residual bagasse from traditional sugar production is currently produced and stored at the sugar mill for use as a fuel within the boiler system. The use of sugarcane fibre also does not impact on the food versus fuel debate as the bagasse is a natural waste product of the sugar production process. The challenge is around the economics of the process for translating this into biofuel.

Transferability

This package of technology will be applicable across many different lignocellulosic biofuel production technologies, as well as for different crops and cropping systems, beyond lignocellulosic material left over after sugarcane processing.

Conclusion and next steps

A confidential Information Memorandum from the project outlines a number of investment opportunities in RD&D within the Australian sugar industry context. It concluded that, in the current market and with available technologies, the production of second generation biofuels from lignocellulosic sugarcane material is not currently competitive. However, there are still compelling arguments for second generation biofuel production in terms of environmental benefits, reduced emissions, and favourable supply chain and distribution infrastructure.

Before further opportunities for this technology can be pursued work is required around:

1. Ensuring sustainable supplies of lignocellulosic raw materials to allow operation of a processing plant beyond the existing sugar season;
2. Reducing operating costs;
3. Develop linkages with national & international groups carrying out relevant RD&D in alternative second generation products and technologies.

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